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February 25, 1836.

HENRY HOLLAND, M.D., Vice-President, in the Chair.

A paper was read, "On an artificial Substance resembling Shell; by Leonard Horner, Esq., F.R.S. L. and Ed.: with an account of the examination of the same; by Sir David Brewster, K.H., LL.D., F.R.S., &c."

The author, having noticed a singular incrustation on both the internal and external surfaces of a wooden dash-wheel, used in bleaching, at the Cotton Factory of Messrs. J. Finlay and Co., at Catrine, in Ayrshire, instituted a minute examination of the properties and composition of this new substance. He describes it as being compact in its texture, of a brown colour, and highly polished surface, with a metallic lustre, and presenting in some parts a beautiful iridescent appearance: when broken, it exhibits a foliated structure. Its obvious resemblance, in all these respects, to many kinds of shell, led the author to inquire into its intimate mechanical structure, and into the circumstances of its formation. He found, by chemical analysis, that it was composed of precisely the same ingredients as shell; namely, carbonate of lime and animal matter. The presence of the former was easily accounted for; as the cotton cloths which are placed in the compartments of the wheel, in order that they may be thoroughly cleansed by being dashed against its sides, during its rapid revolutions, have been previously steeped and boiled in lime water. But it was more difficult to ascertain the source of the animal matter; this, however, was at length traced to the small portion of glue, which, in the factory where the cloth had been manufactured, was employed as an ingredient in forming the paste, or dressing, used to smooth and stiffen the warp before it is put into the loom. These two materials, namely lime and gelatine, being present in the water in a state of extreme division, are deposited very slowly by evaporation; and thus compose a substance which has a remarkable analogy to shell, not only in external appearance, and even pearly lustre, but also in its internal foliated structure, and which likewise exhibits the same optical properties with respect to double refraction and polarizing powers.

A letter from Sir David Brewster, to whom the author had sub-

mitted for examination various specimens of this new substance, is subjoined; giving an account of the results of his investigations of its mechanical and optical properties. He found that it is composed of laminæ, which are sometimes separated by vacant spaces, and at others, only slightly coherent; though generally adhering to each other with a force greater than that of the laminæ of sulphate of lime, or of mica; but less than those of calcareous spar. When the adhering plates are separated, the internal surfaces are sometimes colourless, especially when these surfaces are corrugated or uneven; but they are almost always covered with an iridescent film of the most brilliant and generally uniform tint, which exhibits all the variety of colours displayed by thin plates or polarizing laminæ. This substance, like most crystallized bodies, possesses the property of refracting light doubly; and, as in agate and mother-of-pearl, one of the two images is perfectly distinct, while the other contains a considerable portion of nebulous light, varying with the thickness of the plate, and the inclination of the refracted ray. Like calcareous spar, it has one axis of double refraction, which is negative; and it gives, by polarized light, a beautiful system of coloured rings. It belongs to the rhombohedral system, and, as in the *Chaux carbonatée basée* of Haüy, the axis of the rhombohedron, or that of double refraction, is perpendicular to the surface of the thin plates. As mother-of-pearl has, like arragonite, two axes of double refraction; this new substance may be regarded as having the same optical relation to calcareous spar that mother-of-pearl has to arragonite.

The flame of a candle, viewed through a plate of this substance, presents two kinds of images; the one bright and distinct, the others faint and nebulous, and having curvatures, which vary as the inclination of the plate is changed: the two kinds being constituted by oppositely polarized pencils of light. On investigating the cause of these phenomena, Sir David Brewster discovered it to be the imperfect crystallization of the substance; whence the doubly refracting force separates the incident light into two oppositely polarized pencils, which are not perfectly equal and similar. In this respect, indeed, it resembles agate, mother-of-pearl, and some other substances; but it differs from all other bodies in possessing the extraordinary system of composite crystallization, in which an infinite number of crystals are disseminated equally in every possible azimuth, through a large crystalline plate; having their axes all inclined at the same angle to that of the larger plate, and producing similar phenomena in every direction, and through every portion of the plate: or this remarkable structure may be otherwise described, by saying that the minute elementary crystals form the surfaces of an infinite number of cones, whose axes pass perpendicularly through every part of the larger plate.

An examination of the phenomena of iridescence afforded by this new substance, leads him to the conclusion that the iridescent films are formed at those times when the dash-wheel is at rest, during the night, and that they differ in their nature from the rest of the substance. These phenomena illustrate in a striking manner some ana-

logous appearances of incommunicable colours presented by mother-of-pearl, which had hitherto baffled all previous attempts to explain them; but which now appear to be produced by occasional intermissions in the processs by which the material of the shell is secreted and deposited in the progress of its formation.

March 3, 1836.

The Rev. WILLIAM WHEWELL, M.A., Vice-President, in the Chair.

The Right Hon. the Earl of Minto and Joshua Field, Esq., were elected Fellows of the Society.

A paper was read, entitled, "Researches on the Tides. Fifth Series: On the Solar Inequality, and on the Diurnal Inequality of the Tides at Liverpool." By the Rev. William Whewell, F.R.S., Fellow of Trinity College, Cambridge.

The inequality both in the height and time of high water in the morning and evening tides of the same day, which varies according to a law depending on the time of the year, is termed by the author *the diurnal inequality*, because its cycle is one day. The existence of such an inequality has often been noticed by seamen and other observers; but its reality has only recently been confirmed by regular and measured observations; and its laws have never as yet been correctly laid down. The author gives an account of the observations now in progress at different ports, from which he expects they will be ascertained with great precision. He traces the correspondence of the observations of the diurnal inequality already made with the equilibrium theory; and remarks that the semi-diurnal tides, alternately greater and less, which are transmitted from the Southern Ocean to Liverpool, may be compared to the oscillations of a fluid mass: and that they are augmented by the action of the forces occurring at intervals equal to those of the oscillations. Hence the oscillations go on increasing for a considerable period after the forces have gone on diminishing, and reach their maximum a week after the forces have passed theirs.

The remaining sections of this paper are devoted to the investigation of the Solar inequalities at Liverpool. By carefully eliminating the Lunar effects, which the author is enabled to do by the aid of the preceding researches, he has determined the approximate circumstances of the Solar correction for the height. He has also obtained evidence of the existence, and some knowledge of the laws of the Solar inequalities of the times; and these inequalities, as thus discovered, are found to exhibit the same general agreement with the equilibrium theory which has been disclosed in all the inequalities hitherto detected. The results of the extensive observations now obtained are sufficiently precise to indicate the defects of our mathematical theories of hydrodynamics; and some of these are pointed out by the author, who remarks that although a short time ago the theory

was in advance of observation, at present observation is in advance of theory; which mathematicians are therefore called upon to remodel and perfect.

The author proceeds to consider the effect of the Moon's declination on the Tides at Liverpool; which, as before observed, it is necessary to eliminate, in order to obtain the Solar inequality; and gives an explanation of various formulæ and tables constructed for that object. He then investigates the laws of the solar inequalities, first, as to the heights; and secondly, as to the times of high water at Liverpool, by applying to them these methods of calculation.

March 10, 1836.

FRANCIS BAILY, Esq., Vice-President, and Treas., in the Chair.

Edward John Johnson, Esq., Commander, R.N., was elected a Fellow of the Society.

"Report of Magnetic Experiments tried on board an Iron Steam-Vessel, by order of the Right Hon. the Lords Commissioners of the Admiralty." By Edward J. Johnson, Esq., Commander, R.N., accompanied by plans of the vessel, and tables showing the horizontal deflection of the Magnetic Needle at different positions on board, together with the dip and magnetic intensity observed at those positions, and compared with that obtained on shore with the same instruments. Communicated by Captain Beaufort, R.N., F.R.S., Hydrographer to the Admiralty; by command of the Right Hon. the Lords Commissioners of the Admiralty.

This report commences with a description of the iron steam-vessel, the "Garryowen," belonging to the City of Dublin Steam Packet Company, and built by the Messrs. Laird, of Liverpool. She is constructed of malleable iron, is 281 tons burthen, and draws only 5½ feet water, although the weight of iron in the hull, machinery, &c. is 180 tons.

This vessel was placed under the directions of the author, in Tarbert Bay, on the Shannon, on the 19th of October, 1835, for the purpose of investigating its local attractions on the compass. The methods which were adopted with that view are given; together with tables of the results of the several experiments, and plans of the various parts of the Garryowen. The horizontal deflections of the magnetic needle at different situations in the vessel were observed, for the purpose of ascertaining the most advantageous place for a steering compass, and also for the application of Professor Barlow's correcting plate: and the dip and intensity in these situations were, at the same time, noted.

An experiment is detailed, showing that where several magnetic needles, freely suspended, were placed upon the quay, in Tarbert Bay, and the vessel warped from the anchorage towards them, first with her head in that direction and then with her stern, opposite deflections were produced: in the first case all the needles showing a

deviation to the eastward, and in the latter to the westward, of the true magnetic meridian.

Considering the height of the general mass of iron in the vessel and also that of the head and stern, together with the distance (169 feet) at which some of the needles indicated a deviation, the author concludes that the respective deflections were caused by the magnetic influence of the iron in the vessel; the combined effect of that about the bows representing the north pole of a magnet, and that about the stern a south pole. He then offers several suggestions for future observation on this subject, and connected with the little oxidation that is reported to have taken place in the vessel.

The experiments having been interrupted by a continuance of wet and stormy weather, the author proceeds to draw the following general practical conclusions, deduced from the series of observations already made, and points out the further experiments which he considers necessary to be tried.

1st. The ordinary place for a steering-compass on board ship is not a proper position for it in an iron steam-vessel.

2nd. The binnacle-compass in its usual place on board the Garryowen is too much in error to be depended upon.

3rd. In selecting a proper position for a steering-compass on board iron steam-vessels, attention should be paid to its being placed, as far as is practicable, not only above the general mass of iron, but also above any smaller portions of iron that may be in its vicinity; or such portions of iron should be removed altogether.

4th. The steering-compass should never be placed on a level with the ends either of horizontal or of perpendicular bars of iron.

5th. The extreme ends of an iron vessel are unfavourable positions, in consequence of magnetic influences exerted in those situations. The centre of the vessel is also very objectionable, owing to the connecting rods, shafts, and other parts of the machinery belonging to the steam-engine and wheels, which are in continual motion; independently of the influence exerted by the great iron tunnel in this part of the ship.

6th. No favourable results were obtained by placing the compass either below the deck, or on a stage over the stern.

7th. It was found that at a position 20½ feet above the quarter-deck, and at another 13¼ feet above the same level, and about one seventh the length of the vessel from the stern, the deflections of the horizontal needle were less than those which have been observed in some of His Majesty's ships.

The author proceeds to point out various methods of determining, by means of a more extended inquiry, whether the position above indicated, or one nearer to the deck, is that at which the steering-compass would be most advantageously placed.

The concluding section contains an account of some observations made by the author on the effects of local attraction on board different steam-boats, from which it appears that the influence of this cause of deviation is more considerable than has been generally ima-

gined; and he points out several precautions which should be observed in placing compasses on board such vessels.

'Researches on the Integral Calculus. Part I." By Henry Fox Talbot, Esq., F.R.S.

The author premises a brief historical sketch of the progress of discovery in this branch of analytical science. He observes that the first inventors of the integral calculus obtained the exact integration of a certain number of formulæ only; resolving them into a finite number of terms, involving algebraic, circular, or logarithmic quantities, and developing the integrals of others into infinite series. The first great improvement in this department of analysis was made by Fagnani, about the year 1714, by the discovery of a method of rectifying the differences of two arcs of a given biquadratic parabola, whose equation is $x^4 = y$. He published, subsequently, a variety of important theorems respecting the division into equal parts of the arcs of the lemniscate, and respecting the ellipse and hyperbola; in both of which he showed how two arcs may be determined, of which the difference is a known straight line. Further discoveries in the algebraic integration of differential equations of the fourth degree were made by Euler; and the inquiry was greatly extended by Legendre, who examined and classified the properties of elliptic integrals, and presented the results of his researches in a luminous and well-arranged theory. In the year 1828, Mr. Abel, of Christiana, in Norway, published a remarkable theorem, which gives the sum of a series of integrals of a more general form, and extending to higher powers than those in Euler's theorem; and furnishes a multitude of solutions for each particular case of the problem. Legendre, though at an advanced age, devoted a large portion of time to the verification of this important theorem, the truth of which he established upon the basis of the most rigorous demonstration. M. Poisson has, in a recent memoir, considered various forms of integrals which are not comprehended in Abel's formula.

The problem, to the solution of which the author has devoted the present paper, is of a more general nature than that of Abel. The integrals, to which the theorem of the latter refers, are those comprised in the general expression $\int \frac{P\,dx}{\sqrt{R}}$ where P and R are entire polynomials in x. Next in order of succession to these, there naturally presents itself the class of integrals whose general expression is $\int \frac{P\,dx}{\sqrt[3]{R}}$, where the polynomial R is affected with a cubic, instead of a quadratic radical; but Abel's theorem has no reference to these, and consequently affords no assistance in their solution. The same may be said of every succeeding class of integrals affected with roots of higher powers. Still less does the theorem enable us to find the sum of such integrals as $\int \varphi\,(R)\,dx$; R being, as before, any entire polynomial (that is, containing at least two different powers of x),

and φ being any function whatever. The author then details the processes by which he arrives at the solution of this latter problem.

March 17, 1836.

Sir JOHN RENNIE, Knt., Vice-President, in the Chair.

Major T. Seymour Burt, Bengal Engineers, was elected a Fellow of the Society.

A paper was read, "On the reciprocal attractions of positive and negative electric Currents, whereby the motion of each is alternately accelerated and retarded." By P. Cunningham, Esq., Surgeon R.N. Communicated by Alexander Copland Hutchison, Esq., F.R.S.

The author found that a square plate of copper, six inches in diameter, placed vertically in the plane of the magnetic meridian, and connected with a voltaic battery by means of wires soldered to the middle of two opposite sides of the plate, exhibited magnetic polarities on its two surfaces, indicative of the passage of transverse and spiral electrical currents, at right angles to the straight line joining the ends of the wires. The polarities were of opposite kinds on each side of this middle line, in each surface; and were reversed on the other surface of the plate. The intensities of these polarities at every point of the surface were greatest the greater its distance from the middle line, where the plate exhibited no magnetic action. The author infers from this and other experiments of a similar kind, that each electric current is subject, during its transverse motion, to alternations of acceleration and retardation, the positive current on the one side of the plate and the negative on the other, by their reciprocal attractions, progressively accelerating each other's motions, as they approach, in opposite directions, the edge round which they have to turn. After turning round the edge their motion will, he conceives, be checked by coming in contact with the accelerated portions of the opposing currents to which they respectively owed their former increase of velocity; so that the one current will be retarded at the part of the plate where the other is accelerated. To these alternate accelerations and retardations of electric currents during their progressive motion, the author is disposed to refer the alternate dark and luminous divisions in a platina wire heated by electricity, as was observed by Dr. Barker.

"Meteorological Journal kept at Allenheads, near Hexham." By the Rev. William Walton. Communicated in a letter to P. M. Roget, M.D., Sec. R.S.

This Journal contains a register of the height of the barometer, taken at 9 A.M. and at 3 P.M. during every day in January and February 1836, with remarks on the state of the weather during a few particular days. The station where the observations were made is elevated 1400 feet above the level of the sea.

March 24, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

Richard Beamish, Esq., was elected a Fellow of the Society.

A paper was in part read, entitled "On the Temperatures and Geological Relations of certain Hot Springs; particularly those of the Pyrenees; and on the Verification of Thermometers." By James David Forbes, Esq., F.R.S., Professor of Natural Philosophy in the University of Edinburgh.

The Society then adjourned over the Easter vacation, to meet again on the 14th of April next.

April 14, 1836.

FRANCIS BAILY, Esq., Vice-President and Treasurer, in the Chair.

The reading of Professor Forbes's paper, "On the Temperatures and Geological Relations of certain Hot Springs; particularly those of the Pyrenees; and on the Verification of Thermometers," was resumed and concluded.

The author expresses his regret that notwithstanding the great interest, more especially in a geological point of view, which attaches to every topic connected with the origin, the nature, and the permanence in temperature of the many thermal springs met with in different parts of the world, our information on these subjects is exceedingly deficient. On many points which might easily be verified, and which are of essential consequence towards obtaining a satisfactory theory of the phenomena, we as yet possess but vague and uncertain knowledge. It is evident that the first step towards the establishment of such a theory must consist in the precise determination of the actual temperature of each spring; from which we may derive the means of estimating by comparative observations, at different periods, the progressive variations, whether secular, monthly, or even diurnal, to which that temperature is subject. We have at present, indeed, not only to lament the total absence of exact data on which to found such an inquiry; but we are obliged to confess that, owing to the difficulties which meet us even in the threshhold, we have not, even at the present day, made any preparation for establishing the basis of future investigation, by applying such methods of experiment as are really in our power, and are commensurate with the superior accuracy of modern science. The researches of Fourier would lead us to the conclusion that, if the high temperature of these springs be derived solely from that of the interior portions of the earth, the changes which can have occurred in that temperature, during any period to which history extends, must be so minute as to be inappreciable. On the other hand, the theory of internal chemical changes, which have been assigned as the origin of volcanos, would suggest it as improbable that this temperature has remained constantly the

same; and as a more likely occurrence, even were we to suppose that no uniform secular diminution took place, that it would be liable to occasional irregular fluctuations. The influence of earthquakes on the temperature of hot springs is also admitted; and it would be very desirable to learn, from a series of consecutive observations, whether abrupt changes, similar to those which have occasionally been noticed, are not of frequent occurrence.

The author has diligently laboured to collect, by observations made on the spot, materials for supplying this great chasm in the natural history of our globe. As an essential preliminary means of obtaining accurate results, he applied himself to the verification of the scales of the thermometers he employed in these researches: and he describes, in a separate section of this paper, the methods which he adopted for the attainment of this object. He first fixed with great precision the standard points of each thermometer, namely the freezing and boiling temperatures of water, by a mode which he specifies: and afterwards determined the intermediate points of the scale by a method, similar to that of Bessel; namely, that of causing a detached column of mercury to traverse the tube; but simpler in practice. Instead of employing for that purpose columns of mercury of arbitrary length, and deducing by a complex and tentative process the portions of the tube having equal capacities, the author detaches a column of mercury from the rest, of such a length as may be nearly an aliquot part of the length of the scale for 180°; and causes this column to step along the tube; the lower part of the column being brought successively to the exact points which the upper extremity had previously occupied: so that, at last, if its length has been properly chosen, the upper end of the column is found to coincide with the end of the scale: and this being accomplished, it is easy to apply to every part of the actual scale of the instrument the proper corrections, which may, for greater practical convenience, be drawn up in the form of a table.

In the next section, the author gives a detailed account of his observations of the mineral springs of the Pyrenees, made during the months of July and August, 1835, following them in their natural order from west to east, and describing their geological positions, the special circumstances of interest relating to them, and their actual temperatures.

In the third and last section he extends his inquiries to the hot springs met with in some other parts of Europe; and in particular, those of the baths of Mont d'Or and of Bourboule, in France; of Baden-Baden, in Germany; of Loèsche, or Leuk, in the Vallais; of Pfeffers, in the canton of St. Gall, in Switzerland; and the baths of Nero, near Naples. The final results of all the observations contained in this paper are presented in the form of a table, with comparative columns of those derived from some unpublished observations of M. Arago, and of those of M. Anglada.